other non-GSO systems are proposed in the band in the intervening two years, an item should be added to the WRC-97 Agenda to consider the allocation on a primary basis of sufficient spectrum in the Ka band for non-GSO satellite networks. Even if sufficient spectrum is allocated for non-GSO MSS feeder links at WRC-95, action at WRC-97 might be required to allocate sufficient spectrum for service links for other non-GSO satellite systems. Adoption of this Agenda item is critical if sufficient suitable spectrum is to be identified and made available on a primary basis for all proposed and authorized global non-GSO satellite networks. In this regard, Teledesic recommends that the following item be added to the WRC-97 Agenda:

recognizing

that there is a need to provide equitable access to the Ka band by non-geostationary networks

resolves

to consider allocations and regulatory aspects for non-GSO systems in the Ka band.

V. CONCLUSION

Satellite-based communications networks will play an increasingly important role in extending the benefits of the Information Age to all the world's citizens. Non-GSO satellite systems promise to add to the capabilities of traditional GSO satellites. While the deployment of non-GSO satellite systems raises some challenging new regulatory issues, the potential of these systems for vast humanitarian benefit makes the resolution of these challenges imperative. Technological advances are opening up new frequencies to satellite use. The Ka band, in particular, is the only frequency band internationally allocated to satellite service with sufficient bandwidth to accommodate new broadband satellite systems. Given the increasing importance of non-GSO satellite systems, a non-GSO allocation should be established in the Ka band before the random deployment of GSO systems in the band precludes the option. The issue will be engaged at WRC-95, where a non-GSO satellite allocation is being sought in the band to accommodate feeder links for MSS systems. At a minimum, it must accommodate all non-GSO satellite systems currently proposed in the Ka band including the system proposed by Teledesic. In ascertaining and adopting a position to advocate at WRC-95 on the minimum spectrum requirements for a non-GSO satellite allocation at the Ka band, the FCC either should conduct its own sharing studies or should evaluate the interference analyses that have been conducted by proponents of satellite systems at the Ka band to determine the sharing possibilities among the proposed systems including the Teledesic system. Due to the imminent implementation of GSO satellite systems in various portions of the Ka band, it is critical that action be taken at WRC-95 to allocate spectrum at the Ka band for MSS feeder links using an approach that does not preclude future operation there of non-GSO satellite systems.

Respectfully Submitted,

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CERTIFICATE OF SERVICE

I, Eileen O'Hara, an employee of Akin, Gump, Strauss, Hauer & Feld, L.L.P., certify that copies of the foregoing COMMENTS OF TELEDESIC CORPORATION were sent via First Class Mail or by Hand Delivery on this 6th day of March, 1995, to the following parties:

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APPENDIX A

23 February 1995
Original: English

CHARACTERISTICS OF A LOW-EARTH ORBIT, FSS and MSS NETWORK FOR OPERATION IN THE BANDS 27.5 - 30.0 GHZ AND 17.7 - 20.2 GHZ

1 Introduction

This paper describes the technical characteristics and the system requirements for a proposed network of 924 low-Earth orbit satellites and the associated ground terminals which operate together to provide two-way digital voice, data, and video communications in both the fixed-satellite and the mobile-satellite services. This system proposes to use existing mobile-satellite service (MSS) and fixed-satellite (FSS) frequency allocations with uplinks in the 27.5 - 30.0 GHz band and downlinks in the 17.7 - 20.2 GHz band. The need for separate frequencies to accommodate fixed and mobile applications is not inherent in the network. The same digital broadband capability could be provided to both fixed and mobile applications using the same frequencies through the same terminals. The use of separate bands for FSS and MSS is required to conform with the service distinctions made in current Radio Regulations.

The system as proposed combines non-geostationary orbit, fixed-satellite service (NGSO FSS) and non-geostationary orbit, mobile satellite service (NGSO MSS) within the same network. The concept of NGSO FSS is a departure from previous FSS concepts which used principally geostationary orbit satellites or highly inclined elliptical orbit satellites. While there are several NGSO MSS systems currently under consideration and development, the combining of the two services in the same network introduces new considerations into the planning for spectrum use and system operations. This combining of services in one network requires studies and analyses of the intraservice and the interservice frequency-sharing relationships between this network and other potential users of the same frequency bands, such as, NGSO MSS feeder links, geostationary orbit FSS, and terrestrial fixed service. This document provides information on the technical characteristics of the NGSO FSS and MSS network in sufficient detail to define the planned spectrum use by the network and to support the required sharing studies and analyses.

2 System concept

The proposed network uses a constellation of 840 operational interlinked low-Earth orbit satellites and up to four operational spares per orbital plane to provide global access to a broad range of voice, data and video communication capabilities in the FSS and the MSS. The network will provide switched digital connections between users of the network through a variety of terminals with transmission rates from 16 kbps to 1.24416 Gbps.

The network will provide a quality of service comparable to current terrestrial communication systems meeting G-826 performance and availability recommendations. The system will provide coverage to over 95% of the Earth's surface.

2.1 Constellation description

The satellite constellation is organized into 21 circular orbit planes that are staggered in altitude between 695 and 705 km. Each plane contains a minimum of 40 operational satellites plus up to four on-orbit spares spaced evenly around the orbit. The orbit planes are at a sun-synchronous inclination (approximately 98.2°), which keeps them at a constant angle relative to the sun. The ascending nodes of adjacent orbit planes are spaced at 9.5° around the Equator. Satellites in adjacent planes travel in the same direction except at the constellation "seams", where ascending and descending portions of the orbits overlap. There is no fixed phase relation between satellites in adjacent planes: the position of a satellite in one orbit is decoupled from those in other orbits. The orbital parameters for the system are given in Table 2.1-1.

TABLE 2.1-1

Orbital parameters

Plane #	# of Sats	Alt (km)	Perigee (deg)	Service arc (deg)	RAAN (deg)	Inclination (deg)
1	44	695.0	90	360	0.0	98.142
2	44	695.5	90	360	9.5	98.144
3	44	696.0	90	360	19.0	98.146
4	44	696.5	90	360	28.5	98.148
5	44	697.0	90	360	38.0	98.150
6	44	697.5	90	360	47.5	98.152
7	44	698.0	90	360	57.0	98.154
8	44	698.5	90	360	66.5	98.156
9	44	699.0	90	360	76.0	98.158
10	44	699.5	90	360	85.5	98.160
11	44	700.0	90	360	95.0	98.162
12	44	700.5	90	360	104.5	98.164
13	44	701.0	90	360	114.0	98.166
14	44	701.5	90	360	123.5	98.168
15	44	702.0	90	360	133.0	98.170
16	44	702.5	90	360	142.5	98.172
17	44	703.0	90	360	152.0	98.174
18	44	703.5	90	360	161.5	98.176
19	44	704.0	90	360	171.0	98.178
20	44	704.5	90	360	180.5	98.180
21	44	705.0	90	360	190.0	98.182

As satellite communication links operating in the Ka band frequencies are subject to high rain attenuation and terrain shadowing, the network is designed to operate with high elevation service angles. The attenuation and shadowing problems diminish as the elevation angle of the signal path is increased. The satellite constellation is designed to ensure that there is always at least one satellite visible above a 40° elevation angle over the entire coverage area. Coverage is provided twenty-four hours-a-day between 72° north and south latitude, with partial day coverage to higher latitudes.

This system uses a nominal 700 km altitude to meet the network requirement for low end-to-end delay. The altitudes of satellites in different orbit planes are staggered to eliminate the possibility of collision between satellites in crossing orbits. The nominal 700 km altitude and 40° elevation mask angle yield a satellite footprint approximately 1 400 km in diameter.

The minimum of 40 satellites per plane and 9.5° spacing between planes provides a high degree of coverage redundancy and allows satellites in one plane to be repositioned without opening coverage gaps between planes. Over much of the Earth's surface there will be more than one satellite above the 40° elevation mask angle. Fig. 2.1-1 illustrates the coverage redundancy over the contiguous United States.

2.2 Network considerations

Terminals at gateway and user sites communicate directly with the satellite-based network and through gateway switches, to terminals on other networks. Fig. 2.2-1 is an overview of the network.

Each satellite in the constellation is a node of a fast packet switch network, and has intersatellite communication links with eight adjacent satellites. Each satellite is normally linked with four satellites within the same plane (two in front and two behind) and with one in each of the two adjacent planes on both sides.

FIGURE 2.1-1

Satellite footprint coverage over the contiguous United States

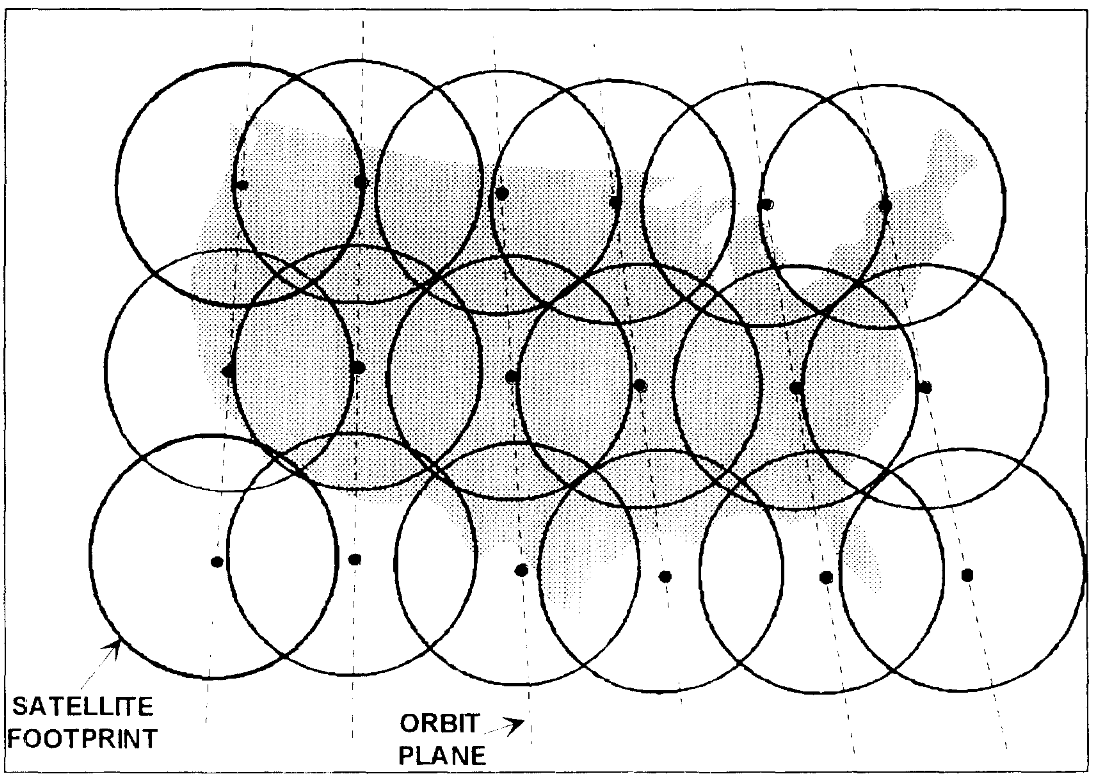
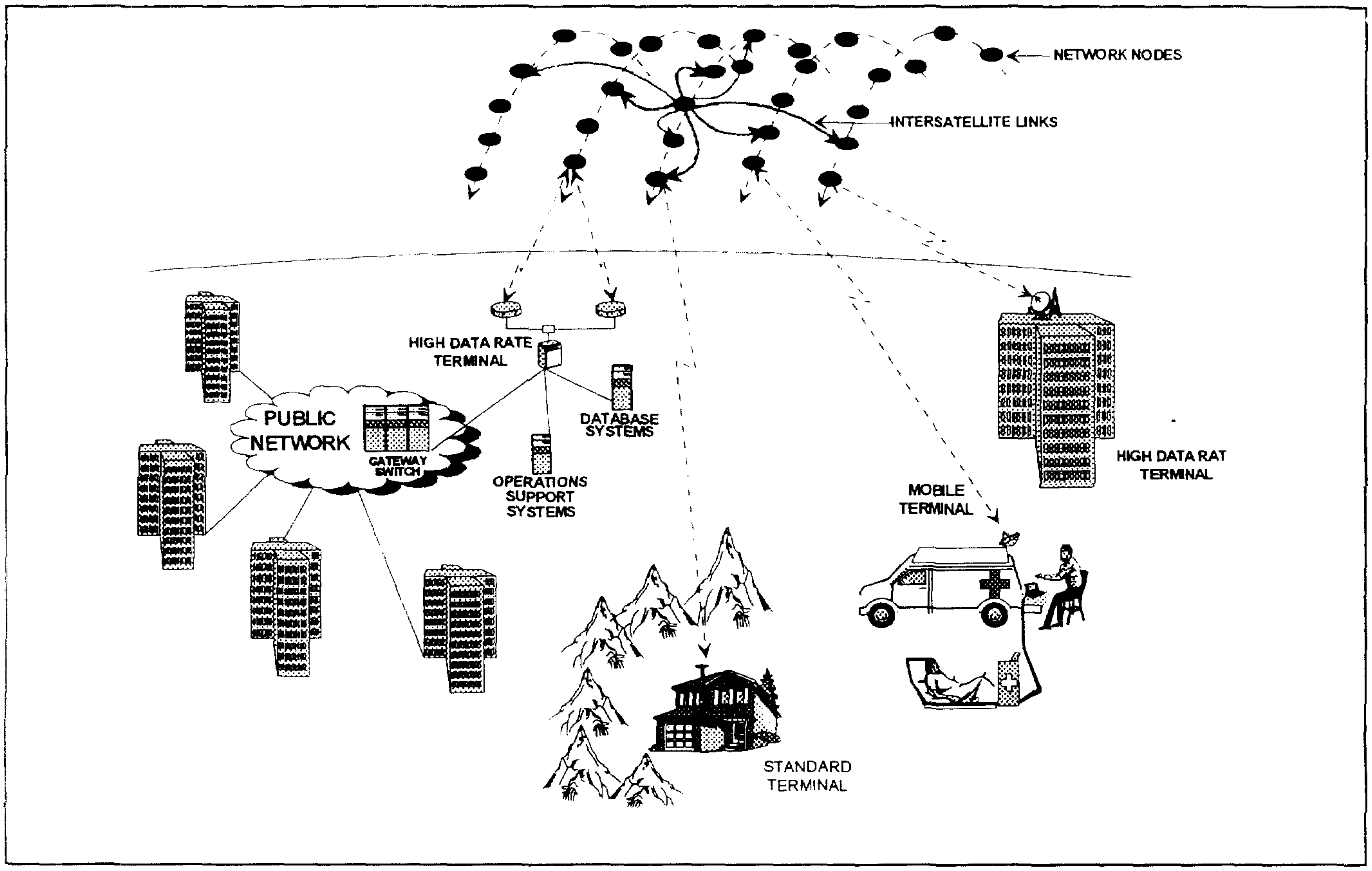


FIGURE 2.2-1

The communication network



2.2.1 Communications links and terminals

All of the communications links transport data and voice as fixed-length (512) bit packets. The basic unit of channel capacity is the "basic channel", which supports a 16 kbps payload data rate and an associated 2 kbps for signalling and control. Basic channels can be aggregated to support higher data rates.

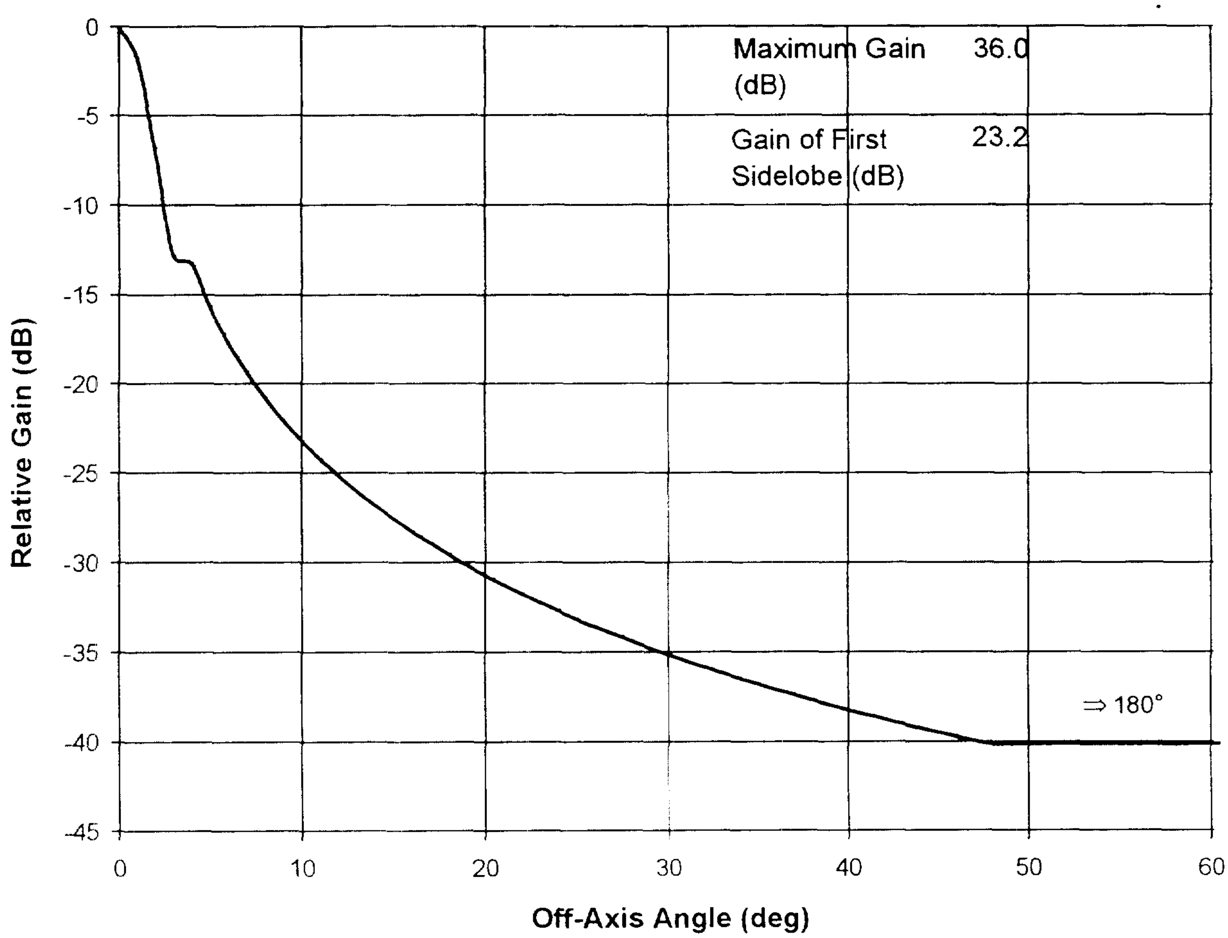
The network will use three types of earth terminals: Standard, Mobile, and High Data Rate. Standard Terminals will include both fixed-site and transportable configurations; and Mobile Terminals will include maritime, aviation, and land mobile configurations.

The uplinks use dynamic power control of the RF transmitters so that the minimum amount of power is used to carry out the desired communication. Minimum transmitter power is used for clear sky conditions. The transmitter power is increased to compensate for rain. Power spectral density produced by the Standard Terminals is -38 dBW/Hz (clear air) and -21 dBW/Hz (rain).

The uplink terminals can use antennas with diameters from 16 cm (8 cm for Mobile Terminals) to 1.8 m as determined by the terminal's maximum transmit channel rate, climatic region, and availability requirements. The average transmit power varies from less than 0.01 W to 4.7 W depending on antenna diameter, transmit channel rate, and climatic conditions. All data rates, up to the full 2.048 Mbps, can be supported with an average transmit power of 0.3 W by suitable choice of antenna size. A typical antenna side-lobe mask is shown in Fig. 2.2.1-1.

FIGURE 2.2.1-1

Typical standard and mobile terminal antenna transmit side-lobe mask (Radiation pattern according to Recommendation 465-3 (1990), with $D/\lambda \approx 25$. Can be modified to agree with Recommendation 465-5 (1993), $G = 32 - 25 \log \phi$)

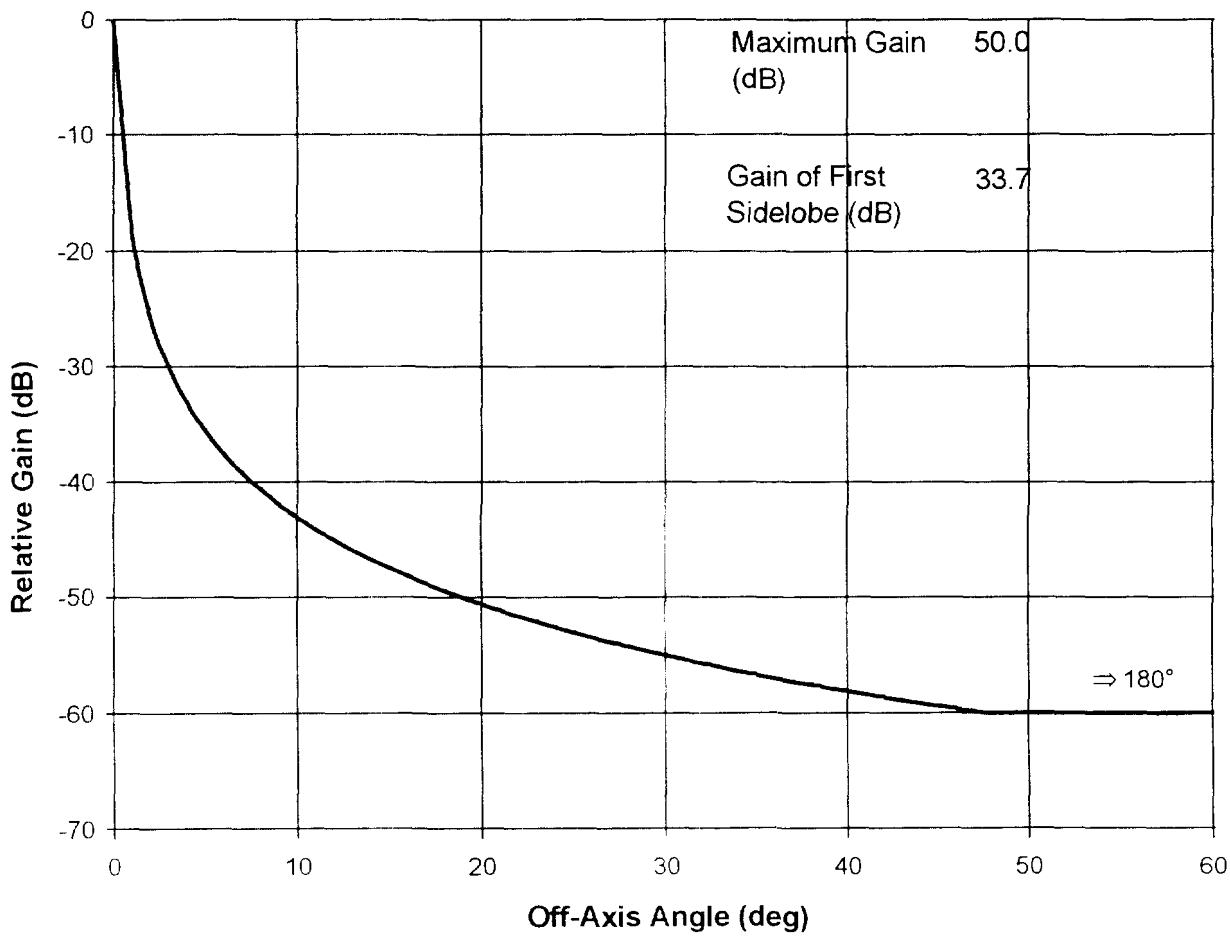


Within its service area, each satellite can support a combination of standard terminals with a total throughput equivalent to over 100 000 simultaneous basic channels. Additionally, each satellite can support mobile terminals with a total throughput equivalent to over 25,000 simultaneous basic channels.

The network also supports a smaller number of fixed-site high data rate terminals that operate at the OC-3 rate ("155.52 Mbps") and multiples of this rate up to OC-24 ("1.24416 Gbps"). Antennas for these terminals can range in size from 28 cm to 1.6 m as determined by the terminal's maximum channel rate, climatic region and availability requirements. Transmit power will range from 1 W to 49 W depending on antenna diameter, data rate, and climatic conditions. Power spectral density produced by a high data rate terminal is -40 dBW/Hz (clear air) and -23 dBW/Hz (rain). The antenna side-lobe mask is shown in Fig. 2.2.1-2.

FIGURE 2.2.1-2

High data rate terminal antenna transmit side-lobe mask (Radiation pattern according to Recommendation 465-5 (1993), with $D/\lambda \approx 135$. $G = 32 - 25 \log \phi$)



A satellite can support up to sixteen high data rate terminals within its service area. Intersatellite Links ("ISLs") interconnect a satellite with eight satellites in the same and adjacent planes. Each ISL operates at 155.52 Mbps, and multiples of this rate up to 1.24416 Gbps depending upon the instantaneous capacity requirement.

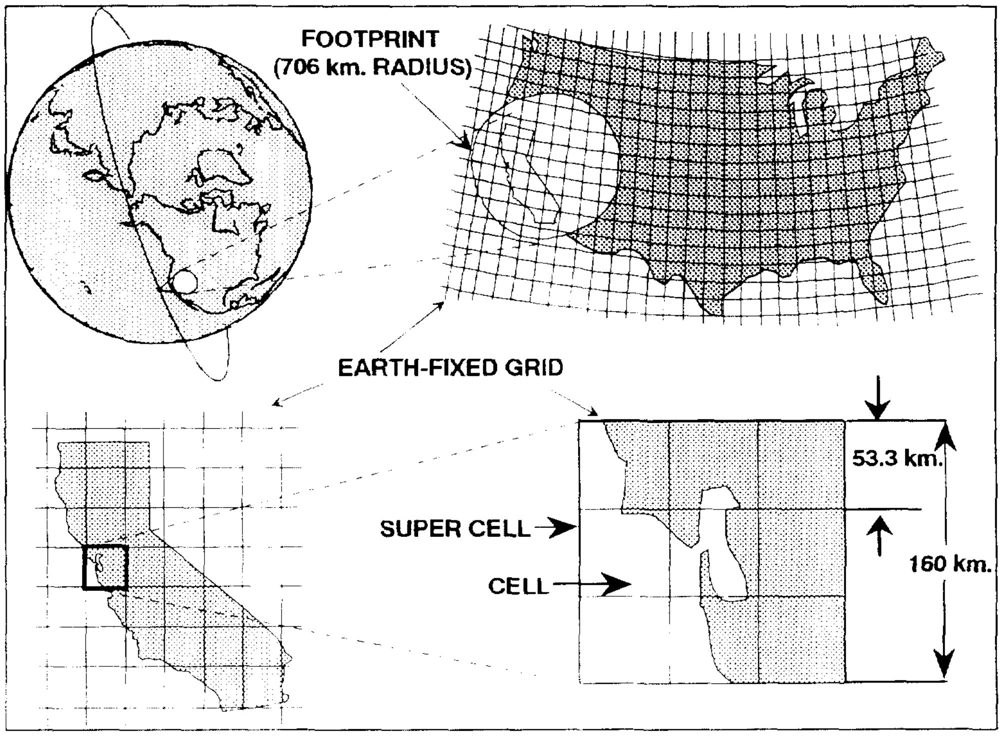
2.2.2 Network structure

One benefit of a small satellite footprint is that each satellite can serve its entire coverage area with a number of high-gain scanning beams, each illuminating a single small cell at a time. Small cells allow efficient reuse of spectrum, high channel density, and low transmitter power. However, if this small cell pattern swept the Earth's surface at the velocity of the satellite (approximately 25 000 km per hour), a terminal would be served by the same cell for only a few seconds before a channel reassignment or "hand-off" to the next cell would be necessary. However, frequent hand-offs result in inefficient channel utilization, high processing costs, and lower system capacity. The network uses an Earth-fixed cell design to minimize the hand-off problem.

The system maps the Earth's surface into a fixed grid of approximately 20 000 "supercells", each consisting of nine cells (see Fig. 2.2.2-1). Each supercell is a square 160 km on each side. Supercells are arranged in bands parallel to the Equator. There are approximately 250 supercells in the band at the Equator, and the number per band decreases with increasing latitude. Since the number of supercells per band is not constant, the "north-south" supercell borders in adjacent bands are not aligned.

FIGURE 2.2.2-1

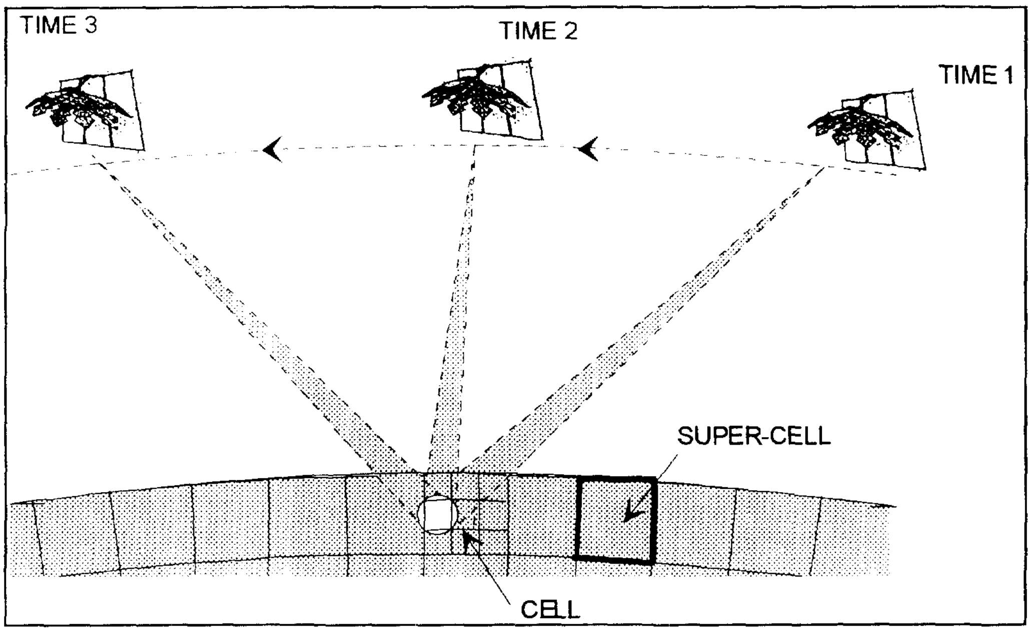
Earth-fixed cells



A satellite footprint encompasses a maximum of 64 supercells, or 576 cells. The actual number of cells for which a satellite is responsible varies by satellite with its orbital position and its distance from adjacent satellites. In general, the satellite closest to the centre of a supercell has coverage responsibility. As a satellite passes over, it steers its antenna beams to the fixed cell locations within its footprint. This beam steering compensates for the satellite's motion as well as the Earth's rotation. This concept is illustrated in Fig. 2.2.2-2.

FIGURE 2.2.2-2

Illustration of beam steering to an Earth-fixed cell



Channel resources (frequencies and time slots) are associated with each cell and are managed by the current "serving" satellite. As long as a terminal remains within the same Earth-fixed cell, it maintains the same channel assignment for the duration of a call, regardless of how many satellites and beams are involved.

A database contained in each satellite defines the type of service allowed within each Earth-fixed cell. Small fixed cells allow the system to avoid interference to or from specific geographic areas and to contour service areas to national boundaries. This would be difficult to accomplish with large cells or cells that move with the satellite.

2.2.3 Multiple access method

The network uses a combination of multiple access methods to ensure efficient use of the spectrum (see Fig. 2.2.3-1). Each cell within a supercell is assigned to one of nine equal time slots. All communication takes place between the satellite and the terminals in that cell during its assigned time slot. Within each cell's time slot, the full frequency allocation is available to support communication channels. The cells are scanned in a regular cycle by the satellite's transmit and receive beams, resulting in time division multiple access ("TDMA") among the cells in a supercell. Since propagation delay varies with path length, satellite transmissions are timed to ensure that cell N (N=1, 2, 3, ...9) of all supercells receive transmissions at the same time. Terminal transmissions to a satellite are also timed to ensure that transmissions from the same numbered cell in all supercells in its coverage area reach that satellite at the same time. Physical separation (space division multiple access or "SDMA") and a checkerboard pattern of left and right circular polarization eliminate interference between cells scanned at the same time in adjacent supercells. Guard time intervals eliminate overlap between signals received from time-consecutive cells.

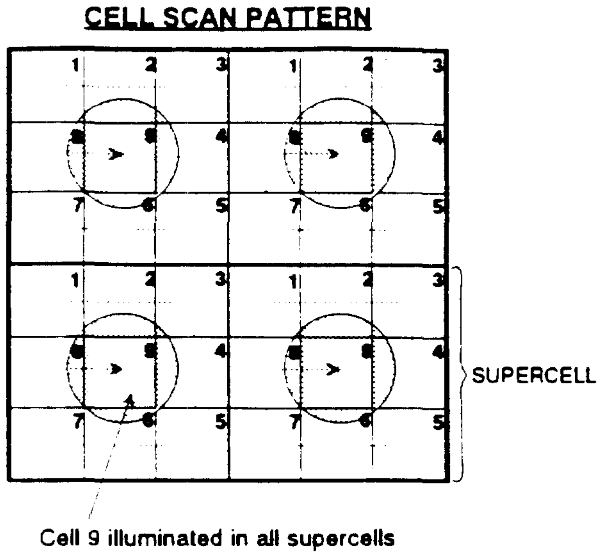
Within each cell's time slot, terminals use Frequency Division Multiple Access ("FDMA") on the uplink and Asynchronous Time Division Multiple Access ("ATDMA") on the downlink. On the uplink, each active terminal is assigned one or more frequency slots for the call's duration and can send one packet per slot each scan period (23.111 msec). The number of slots assigned to a terminal determines its maximum available transmission rate. One slot corresponds to a Standard Terminal's or Mobile Terminal's 16 kbps basic channel with its associated 2 kbps signalling and control channel. A total of 1 440 slots per cell scan interval are available for Standard Terminals and 360 for Mobile Terminals.

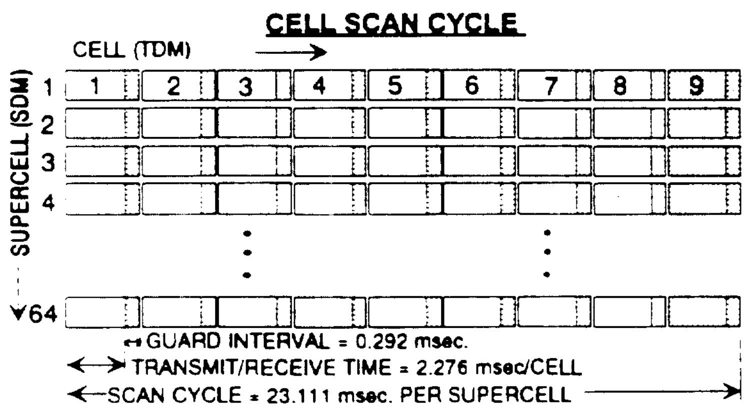
The terminal downlink uses the packet's header rather than a fixed assignment of time slots to address terminals and is timeshared between the Standard Terminals and the Mobile Terminals. During each cell's scan interval the satellite transmits a series of packets addressed to terminals within that cell. Packets are delimited by a unique bit pattern, and a terminal selects those addressed to it by examining each packet's address field. A Standard Terminal or Mobile Terminal operating at 16 kbps requires one packet per scan interval. The downlink capacity is 1 440 packets per cell per scan interval for Standard Terminals or 360 packets per cell per scan interval for Mobile Terminals, or some combination.. The satellite transmits only as long as it takes to send the packets queued for a cell.

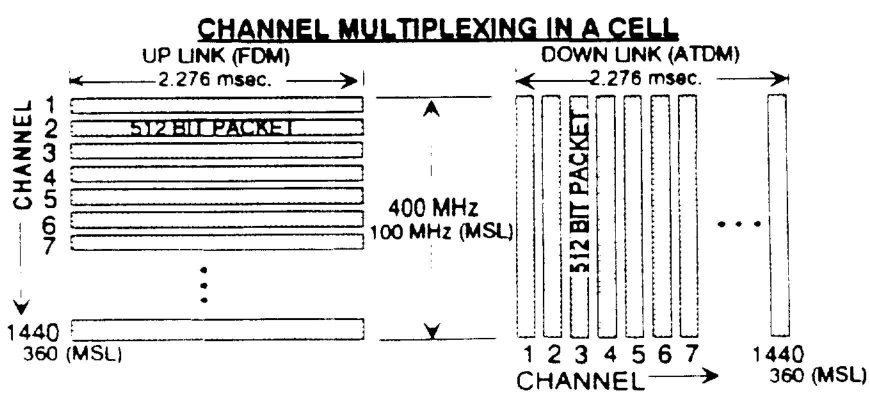
The combination of Earth-fixed cells and multiple access methods results in very efficient use of spectrum. The system can reuse its requested spectrum over 20 000 times across the Earth's surface.

FIGURE 2.2.3-1

Standard and Mobile Terminal multiple access method







3 Technical characteristics

3.1 RF plan

For each link, the operating frequency bands, specific operating frequencies, and the total bandwidth are shown in Table 3.1-1. The centre frequencies are shown in Table 3.1-2. The frequencies marked with an asterisk are assigned for communications requiring an even number of channels, the unmarked frequencies are assigned for odd numbers of channels. Centre frequencies are always assigned in a manner that insures that no out-of-band transmissions occur.

Table 3.1-1 - Frequency Bands, Requested Frequencies, and Total Bandwidth

	Frequency Band	Requested Frequencies	Total Requested Bandwidth
Standard Terminal Uplink	27.5 - 30.0 GHz	28.6 - 29.0 GHz	400 MHz
Standard Terminal Downlink	17.8 - 18.6 GHz & 18.8 - 20.2 GHz	18.8 - 19.2 GHz	400 MHz
Mobile Terminal Uplink *	29.5 - 30.0 GHz	29.5 - 29.6 GHz	100 MHz
Mobile Terminal Downlink *	19.7 - 20.2 GHz	19.7 - 19.8 GHz	100 MHz
High Data Rate Uplink & Command Uplink	27.5 - 30.0 GHz	27.6 - 28.4 GHz	800 MHz
High Data Rate Downlink & Telemetry Downlink	17.8 - 18.6 GHz & 18.8 - 20.2 GHz	17.8 - 18.6 GHz	800 MHz
ISL	59 - 64 GHz	59.5 - 60.5 GHz & 62.5 - 63.5 GHz	2000 MHz

* Moble Satellite Service currently not proposed for the United States

Table 3.1–2. Proposed Center Frequencies

Standard Terminal Uplink	28.6001375 GHz, 28.6002750 GHz*, 28.6004125 GHz, 28.6005500 GHz*, ..., 28.9958625 GHz
Standard Terminal Downlink	18.998 GHz
Mobile Terminal Uplink	29.5001375 GHz, 29.5002750 GHz*, 29.5004125 GHz, 29.5005500 GHz*, ..., 29.5958625 GHz
Mobile Terminal Downlink	19 75 GHz
High Data Rate Uplink & Command Uplink	27 65 GHz, 27.7 GHz*, 27.75 GHz, 27.8 GHz*, 27 85 GHz, 27.9 GHz*, 27.95 GHz, 28 GHz*, 28.05 GHz, 28 1 GHz*, 28 15 GHz, 28.2 GHz*, 28.25 GHz, 28.3 GHz*, 28.35 GHz
High Data Rate Downlink & Telemetry Downlink	17 85 GHz, 17.9 GHz*, 17.95 GHz, 18.0 GHz*, 18.05 GHz, 18.1 GHz*, 18.15 GHz 18.2 GHz*, 18.25 GHz, 18.3 GHz*, 18.35 GHz, 18.4 GHz*, 18.45 GHz, 18.5 GHz*, 18.55 GHz
ISL	59.5625 GHz, 59.625 GHz*, 59.6875 GHz, 59.75 GHz*, 59.8125 GHz, 59.875 GHz*, 59.9375 GHz, 60 GHz*, 60.0625 GHz, 60.125 GHz*, 60.1875 GHz, 60.25 GHz*, 60.3125 GHz, 60.375 GHz*, 60.4375 GHz, 62.5625 GHz, 62.625 GHz*, 62.6875 GHz, 62.75 GHz*, 62.8125 GHz, 62.875 GHz*, 62.9375 GHz, 63 GHz*, 63.0625 GHz, 63 125 GHz*, 63.1875 GHz, 63.25 GHz*, 63.3125 GHz, 63.375 GHz*, 63.4375 GHz

For each link, the polarizations are shown in Table 3.1-3 and the emission designators in Table 3.1-4. The satellite transmitter output powers and maximum e.i.r.p.s for each antenna beam are shown in Table 3.1-5. The transmit power levels are referenced to the antenna inputs. Thus, there are no net losses prior to the input of the antennas.

TABLE 3.1-3

Polarizations

Table 3.1-3. Polarizations

Standard Terminal Uplink	RHC & LHC
Standard Terminal Downlink	RHC & LHC
Mobile Terminal Uplink	RHC & LHC
Mobile Terminal Downlink	RHC & LHC
High Data Rate Uplink	RHC & LHC
High Data Rate Downlink	RHC & LHC
ISL	RHC & LHC
Command Uplink	Vertical
Telemetry Downlink	Vertical

Table 3.1–4. Emission Designators

Standard Terminal Uplink	275KG1D, 550KG1D, 825KG1D, 1M10G1D, ..., 35M2G1D
Standard Terminal Downlink	396MG7D
Mobile Terminal Uplink	275KG1D, 550KG1D, 825KG1D, 1M10G1D, ..., 35M2G1D
Mobile Terminal Downlink	99M0G7D
GigaLink Uplink	100MG7D, 200MG7D, 300MG7D, 400MG7D, 500MG7D, 600MG7D, 700MG7D, 800MG7D
GigaLink Downlink	100MG7D, 200MG7D, 300MG7D, 400MG7D, 500MG7D, 600MG7D, 700MG7D, 800MG7D
ISL	125MG7D, 250MG7D, 375MG7D, 500MG7D, 625MG7D, 750MG7D, 875MG7D, 1G00G7D
Command Uplink	100KF1D
Telemetry Downlink	100KF1D

TABLE 3.1-5

Satellite transmitter output power and maximum e.i.r.p.

	Transmit power	**Maximum e.i.r.p.**
TSL/MSL		
Centre	75 W	48.6 dBW
Middle ring	75 W	49.7 dBW
Edge	75 W	50.8 dBW
GSL	4.6 W	47.6 dBW
ISL	5.5 W	55.4 dBW
Telemetry	2 W	3.0 dBW

The satellites are processing satellites. They demodulate and decode all received packets. The decoded packets are routed by a digital switch, encoded, modulated and retransmitted. The satellites do not contain conventional bent-pipe transponders. Thus the concepts of saturation flux density and transponder gain have no meaning in the proposed system.

Received packets can be routed to any of the antenna beams by the digital fast packet switch. The satellite receiving system noise temperature, receiver antenna gain, and gain-to-temperature (G/T) ratio for each antenna beam are shown in Table 3.1-6.

TABLE 3.1-6

Satellite receiving system noise temperature, gain and G/T

	Receiving system noise temperature	**Receive antenna gain**	**G/T**
TSL/MSL			
Centre	652 K	29.8 dB	1.7 dB/K
Middle ring	652 K	30.9 dB	2.8 dB/K
Edge	652 K	32.0 dB	3.9 dB/K
GSL	652 K	41 dB	12.9 dB/K
ISL	545 K	48 dB	20.6 dB/K
Command	652 K	0 dB	-28.1 dB/K

The satellite receivers incorporate appropriate input filtering to minimize noise effects from outside the assigned frequency bands. The satellite transmitters incorporate output filtering to minimize out-of-band spurious transmissions down to levels of 65 dB below the carrier power levels.

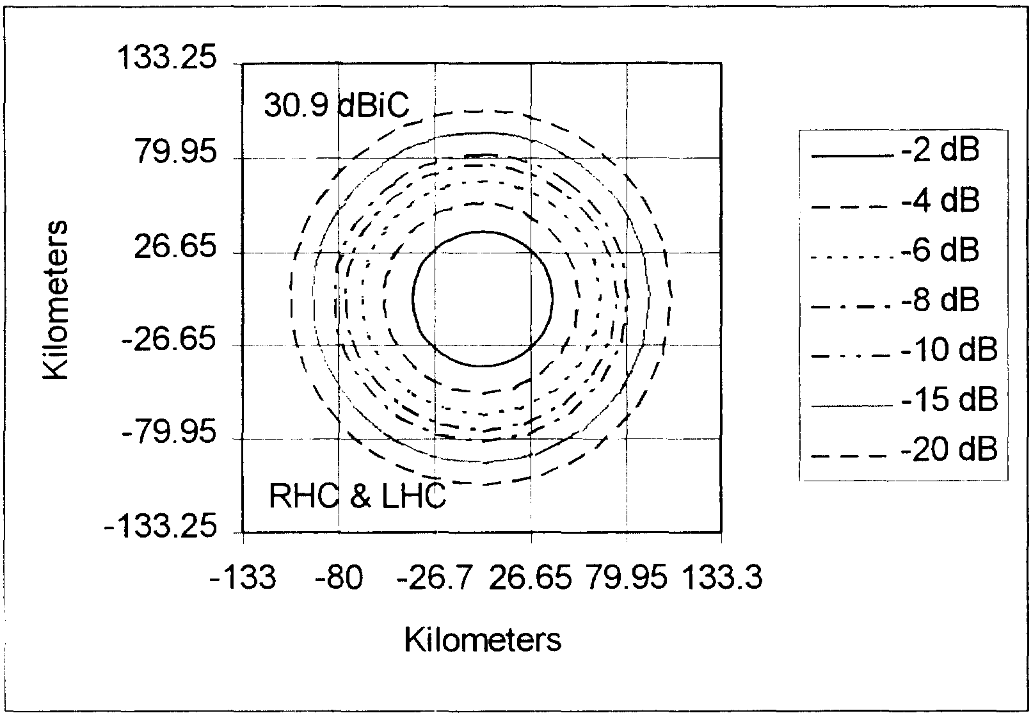
3.2 Space station antenna gain contours

Each satellite scanning beam antenna system consists of 64 transmit and 64 receive scanning beams plus spares. Typical gain contours for the transmit and the receive beams are shown in Fig. 3.2-1. The antenna side lobes are down a minimum of 30 dB for off-axis angles greater than 11°. The scanning beam communications subsystem supports the Standard Terminal links and the Mobile Terminal links. It consists of 64 transmit channels and 64 independent receive channels. The transmitters are time shared between the Standard Terminals and the Mobile Terminals, and the receivers are shared by frequency division.

FIGURE 3.2-1

Satellite scanning beam transmit and receive gain contours, middle ring of footprint

e.i.r.p. (dBW) = Gain + 18.8 dBW **G/T (dB/K) = Gain - 28.1 dBK**

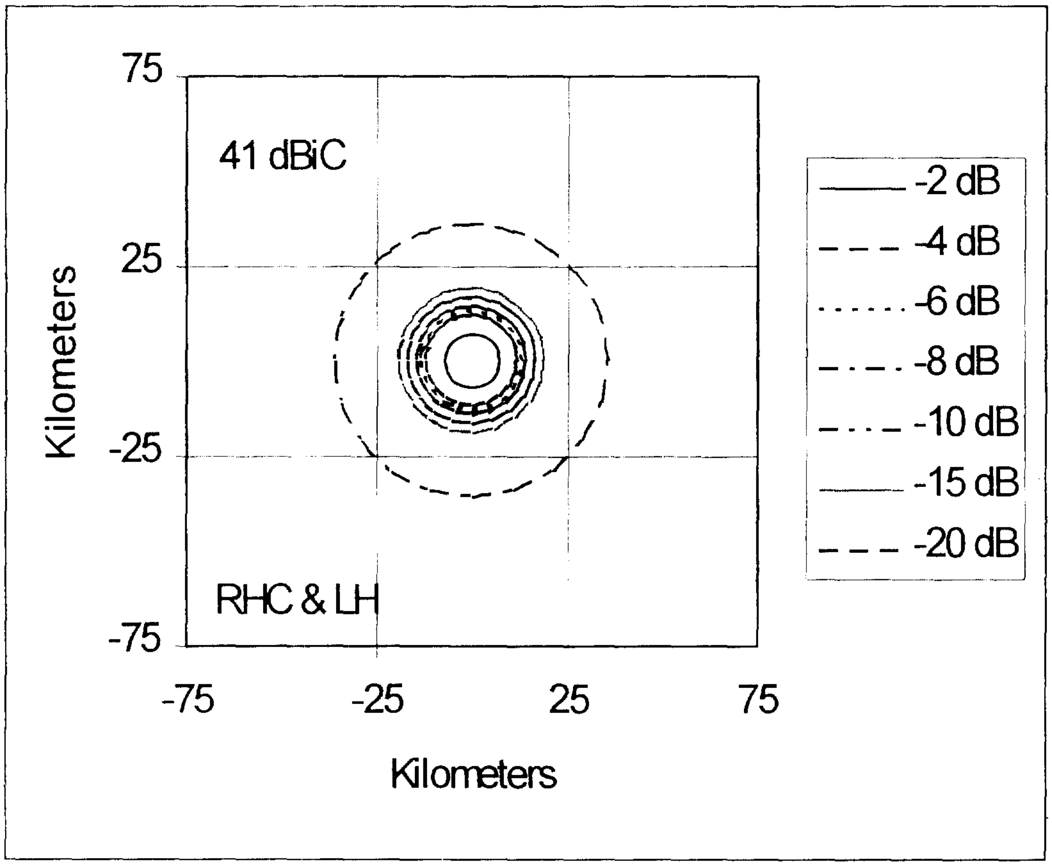


Each satellite Ground to Satellite Link (GSL) antenna system consists of 16 transmit/receive beam pairs plus spares. The beams can be used in tandem to provide dual spatial diversity. Gain contours for the transmit and receive beams are shown in Fig. 3.2-2. The antenna side lobes are down a minimum of 30 dB for off-axis angles greater than 3°.

FIGURE 3.2-2

Satellite GSL transmit and receive beam gain contours

e.i.r.p. (dBW) = Gain + 6.6 dBW **G/T (dB/K) = Gain - 28.1 dBK**

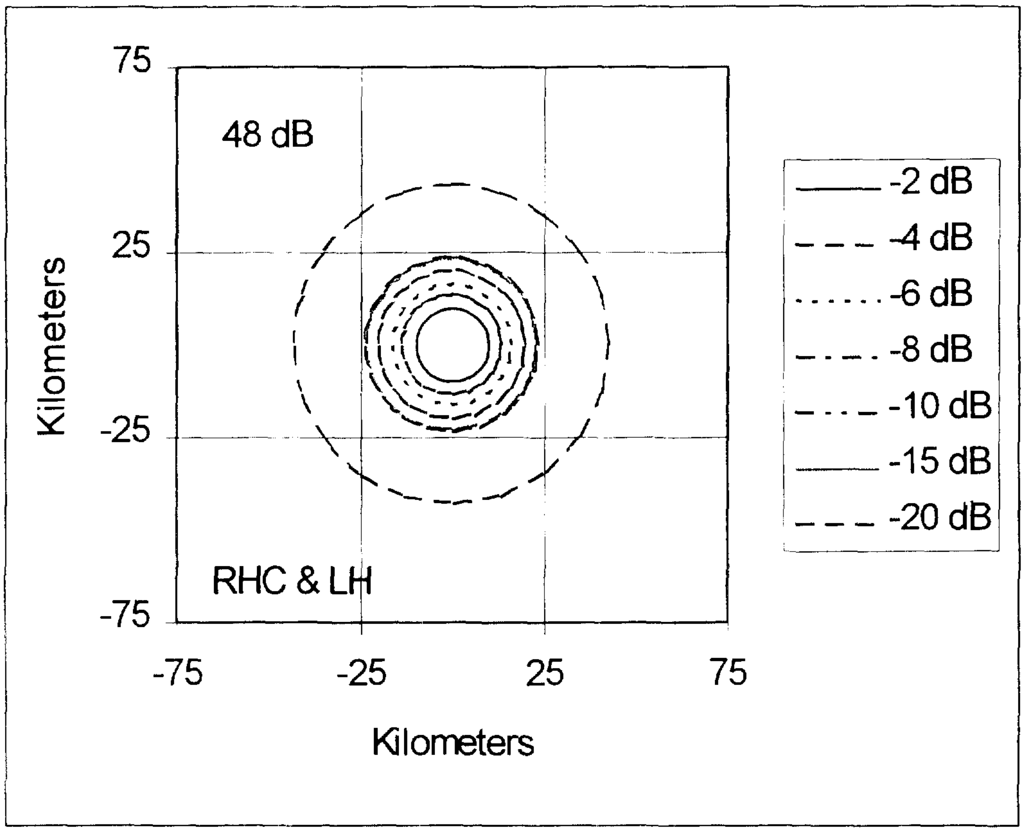


Each satellite ISL antenna system consists of eight transmit and eight receive beams plus spares. The transmit and receive antenna beam gain is 48 dBiC peak. The predicted gain contours for the transmit and the receive beams at maximum range (2 586 km) are shown in Fig 3.2-3.

FIGURE 3.2-3

ISL transmit and receive gain contours at maximum range

e.i.r.p. (dBW) = Gain + 7.4 dBW **G/T (dB/K) = Gain - 27.4 dBK**



3.3 Performance

The Terminal to Satellite Links (TSLs) and the Mobile to Satellite Links (MSLs) use QPSK modulation with error control coding and require an E_b/N_0 of 4.5 dB to meet a bit error rate (BER) of 10^{-9}. The GSLs and ISLs use 8-PSK modulation with error control coding and require an E_b/N_0 of 10 dB. All communications links are designed to operate at a carrier-to-interference ratio of 25 dB. The uplink and downlink burst data rates are shown in Table 3.3-1.